The compensatory mechanism in high-angle malocclusions: A comparison of subjects in the mixed and permanent dentition

Dörthe Betzenberger, DDS, Dr. med. dent.; Sabine Ruf, DDS, Dr. med. dent.; Hans Pancherz, DDS, Odont. Dr.

Abstract: Dentoskeletal morphology was assessed in 191 untreated and unselected children with a hyperdivergent (high-angle) mandibular plane (ML/NSL ≥40 degrees) by analyzing lateral roentgenographic cephalograms. The subjects were divided into mixed dentition and permanent dentition groups, and further divided into subgroups based on the amount of overbite (OB) as a measure of dentoalveolar compensation of jaw base hyperdivergency: OB < 0 mm (openbite) = insufficient/no compensation; OB 0 to 4 mm (normal overbite) = acceptable compensation; OB > 4 mm (deepbite) = overcompensation. Openbite was observed in 20% of the children, normal overbite in 50%, and deepbite in 30%. Skeletally, the deepbite mixed dentition group was characterized by a relatively posterior inclination of the maxilla, while the deepbite permanent dentition group had a relatively anterior inclination of the mandible. Dentoalveolar compensation was accomplished by relative increases in maxillary and mandibular anterior dentoalveolar heights in the mixed dentition group and by relative decreases in maxillary and mandibular posterior dentoalveolar heights in the permanent dentition. Positive overbite was found in the majority (80%) of children with high-angle morphology. Thus, mandibular hyperdivergency is frequently compensated for. Skeletal characteristics and dentoalveolar compensatory mechanisms differ with dental maturity and seem to be influenced by mouth breathing and other oral habits.

Key Words: Compensation, High-angle malocclusion, Skeletal, Dentoalveolar , Mixed dentition, Permanent dentition

High-angle malocclusion, also discussed under the headings of hyperdivergency,[1] long-face syndrome,[2] and adenoid face,[3] is characterized by increased inclination of the mandible in relation to anterior cranial base.[1] According to Riedel,[4] a high-angle malocclusion is present in individuals exhibiting a mandibular plane angle (ML/NSL) greater than 38 degrees.

Schendel et al.[2] claimed that in adult patients, openbite and deepbite are two variants of long-face syndrome. Solow[5] attributed this to a process of dentoalveolar compensation in which the teeth and alveolar processes adapt to varying jaw-base relationships, maintaining a functional occlusion despite increased divergence of the jaw bases.

Only a few systematic investigations of the mechanism of dentoalveolar compensation in high-angle malocclusions in adults[2,6] and juveniles[7,8] have been performed, and the juvenile studies were restricted to comparisons of different vertical facial types.

Therefore, the aim of this study was to analyze skeletal characteristics in growing high-angle individuals at different stages of dental maturity, and to assess possible dentoalveolar compensatory mechanisms for the high-angle pattern.

Material and methods

The subject material was selected from the total patient material of the Department of Orthodontics at the University of Giessen, pre-1995. All children who had lateral headfilms available, a hyperdivergent mandibular plane angle (ML/NSL ≥ 40° based on pretreatment lateral headfilms in habitual occlusion), and in whom all permanent incisors and first permanent molars had erupted were surveyed. Patients with evidence of craniofacial anomalies, severe respiratory problems (asthma, cystic fibrosis, etc.), a history of craniofacial trauma, and those who had received orthodontic treatment were excluded because of possible influences on the vertical development of the dentoalveolar processes or the dimension of the midface structures.[9-11] Furthermore, in order to avoid major differences in craniofacial morphology due to ethnicity, only children from Central Europe were

Author Address
Dr. Sabine Ruf
Dept. of Orthodontics
Justus-Liebig-University of Giessen
Schlangenzahl 14
D-35392 Giessen, Germany

Dörthe Betzenberger, assistant professor, Department of Orthodontics, University of Giessen, Germany.

Sabine Ruf, assistant professor, Department of Orthodontics, University of Giessen, Germany.

Hans Pancherz, professor and chair, Department of Orthodontics, University of Giessen, Germany.

Submitted: September 1997; **Revised and accepted:** February 1998
Angle Orthod 1999;69(1):27-32.

surveyed. One hundred ninety-one subjects met the selection criteria and were included in the study.

The subjects were divided into two groups according to dental maturity: mixed dentition and permanent dentition. These groups were further divided into subgroups based on the amount of overbite (OB) as a measure of dentoalveolar compensation:

OB < 0 mm; openbite high-angle group (insufficient/no compensation)

OB = 0 - 4 mm; normal overbite high-angle group (acceptable compensation)

OB > 4 mm; deepbite high-angle group (overcompensation)

The distribution of subjects in the two dental maturity groups and the overbite subgroups is shown in Table 1.

Pretreatment lateral headfilms were traced, digitized, and analyzed cephalometrically by one investigator (DB) using the computer program Dentofacial Planner 5.3. The linear enlargement (6%) of the headfilms was corrected for in the analysis. The reference points and planes used and the variables measured are shown in Figure 1. In assessing vertical facial morphology, the following skeletal and dentoalveolar variables were used.

Skeletal variables

ML/NSL (degrees): Inclination of mandibular jaw base (ML) to cranial base (NSL) (= mandibular plane angle)

NL/NSL (degrees): Inclination of maxillary jaw base (NL) to cranial base (NSL) (= maxillary plane angle)

ML/NL (degrees): Inclination of maxillary jaw base (NL) to mandibular jaw base (ML) (= interjaw-base angle)

s-go (mm): Posterior total facial height

n-gn (mm): Anterior total facial height

n-spa (mm): Anterior upper facial height

spa-gn (mm): Anterior lower facial height

Dentoalveolar variables

is-NL (mm): Distance of the tip of the most extruded upper incisor (is) to maxillary jaw base (NL)

isa-NL (mm): Distance of the apical point of the most extruded maxillary incisor (isa) to maxillary jaw base (NL)

ii-ML (mm): Distance of the tip of the most extruded mandibular incisor (ii) to mandibular jaw base (ML)

iia-ML (mm): Distance of the apical point of the most extruded mandibular incisor (iia) to mandibular jaw base (ML)

ms-NL (mm): Distance of the mesial cusp tip of the maxillary first molar (ms) to maxillary jaw base (NL)

msa-NL (mm): Distance of the apical point of the mesial root of the maxillary first molar (msa) to maxillary jaw base (NL)

mi-ML (mm): Distance of the mesial cusp tip of the mandibular first molar (mi) to mandibular jaw base (ML)

mia-ML (mm): Distance of the apical point of the mesial root of the mandibular first molar (mia) to mandibular jaw base (ML)

Habits

The presence of various habits, such as mouth breathing, finger or lip sucking, or tongue-thrust swallowing[12] was registered anamnestically and clinically at the time the profile roentgenograms were taken.

Statistical methods

For each cephalometric variable the arithmetical mean (mean) and the standard deviation (SD) were determined. To analyze the statistical differences between various subject groups the Student's t-test for unpaired samples was applied. The correlation coefficient r (Pearson) was used to describe the interrelationship between the overbite and the skeletal and dentoalveolar variables.

$|r| >$ 0.80 strong correlation

$|r| =$ 0.40 - 0.80 moderate correlation

$|r| <$ 0.40 weak correlation

In the statistical evaluation, the following levels of significance were used: ***= $p < 0.001$; **= $p < 0.01$; *= $p < 0.05$; n.s. = $p \geq 0.05$ (not significant).

To determine the method error (me), lateral headfilms from 20 randomly selected subjects were traced and digitized twice. Dahlberg's formula[13] was used to calculate the method error:

$$me = \sqrt{\frac{\sum d^2}{2n}}$$

, where d is the difference between two measurements of a pair and n is the number of subjects.

The digitizing error (the same tracing digitized twice) did not exceed 0.5 degrees or 0.2 mm. The combined tracing and digitizing error (the same headfilm traced and digitized twice) did not exceed 0.8 degrees or 0.8 mm.

Table 1
Distribution (percentage and number) of 191 "high-angle" subjects (ML/NSL ≥ 40°) in two dental maturity groups and three overbite subgroups

Overbite	Dental maturity	
	Mixed dentition	Permanent dentition
(mm)	(n = 144)	(n = 47)
< 0	9% (13)	21.3% (10)
0 - 4	50.7% (73)	46.8% (22)
> 4	40.3% (58)	31.9% (15)

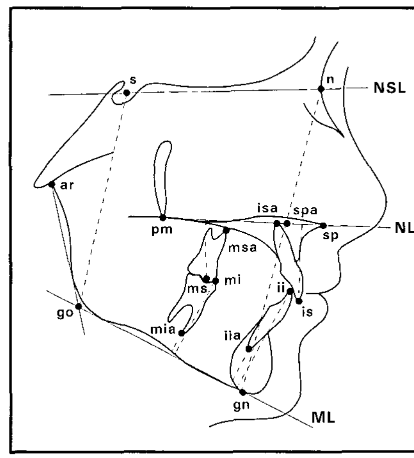

Figure 1
Cephalometric reference points, reference lines, and skeletal and dentoalveolar variables

Table 2
Cephalometric records from 71 high-angle subjects in the mixed dentition and 25 high-angle subjects (ML/NSL ≥ 40°) in the permanent dentition. A comparison of cases with insufficient/no compensation (openbite) and overcompensation (deepbite)

Variable	Mixed dentition Openbite (o) n = 13 Mean	SD	Deepbite (d) n = 58 Mean	SD	Group diff (o-d) D Mean (D)	t-value		Permanent dentition Openbite (o) n = 10 Mean	SD	Deepbite (d) n = 15 Mean	SD	Group diff (o-d) D Mean (D)	t-value	
Subject selection														
ML/NSL (deg)	42.5	2.44	43.7	2.94	-1.2	-1.37	n.s.	45.7	3.59	42.5	1.59	3.2	3.02	**
Overbite (mm)	-1.5	1.41	6.1	1.27	-7.6	-19.21	***	-2.3	1.19	5.6	1.15	-7.9	-16.41	***
Skeletal														
NL/NSL (deg)	7.3	2.19	9.5	3.07	-2.2	-2.48	*	9.2	4.52	9.3	2.81	-0.1	-0.03	n.s.
ML/NL (deg)	35.3	3.65	34.2	3.87	1.1	0.88	n.s.	36.5	5.35	33.3	2.54	3.2	2.02	*
s - go (mm)	61.3	3.05	62.5	4.02	-1.2	-0.96	n.s.	72.5	6.52	67.5	3.52	5.0	2.49	*
n - gn (mm)	102.6	4.39	106.0	5.59	-3.4	-2.08	*	121.0	8.29	112.1	5.92	8.9	3.14	**
n - spa (mm)	44.9	2.2	48.3	2.98	-3.4	-3.88	***	51.7	2.81	50.2	3.51	1.5	1.11	n.s.
spa - gn (mm)	57.7	3.22	57.8	3.59	-0.1	-0.06	n.s.	69.3	7.12	62.0	3.28	7.3	3.52	**
Dentoalveolar														
is-NL (mm)	24.4	2.14	28.2	2.17	-3.8	-5.74	***	28.5	3.72	29.0	1.85	-0.5	-0.38	n.s.
isa-NL (mm)	2.0	2.04	3.9	1.77	-1.9	-3.46	***	6.3	2.26	6.5	2.06	-0.2	-0.23	n.s.
ms-NL (mm)	18.3	1.36	19.0	1.88	-0.7	-1.19	n.s.	25.0	2.87	21.2	2.01	3.8	3.91	***
msa-NL (mm)	0.2	1.11	0.7	1.67	-0.5	-1.01	n.s.	6.0	2.89	3.1	1.89	2.9	3.01	**
ii-ML (mm)	35.2	2.32	38.3	2.31	-3.1	-4.41	***	39.4	2.62	40.2	2.47	-0.8	-0.78	n.s.
iia-ML (mm)	13.7	1.92	15.6	2.22	-1.9	-2.83	**	17.9	2.95	18.5	2.31	-0.6	-0.61	n.s.
mi-ML (mm)	27.6	1.79	27.3	1.76	0.3	0.72	n.s.	31.6	3.52	29.1	2.47	2.5	2.08	*
mia-ML (mm)	8.3	1.56	7.4	1.62	0.9	1.82	n.s.	12.6	3.18	9.4	2.45	3.2	2.82	**

*** = $p < 0.001$
** = $p < 0.01$
* = $p < 0.05$
n.s. = not significant

Results

Of the total material of 191 high-angle subjects, 9% exhibited a frontal openbite (OB < 0 mm) in the mixed dentition and 21% did so in the permanent dentition (Table 1). Nearly half the subjects in both dental maturity groups showed a normal overbite (OB 0 - 4 mm), and more than one-third of the cases presented a deepbite (OB > 4 mm).

For further analysis of the skeletal characteristics and the dentoalveolar compensatory mechanism, the openbite and deepbite high-angle groups were compared. Skeletal and dentoalveolar variables were evaluated separately.

Skeletal characteristics

In the mixed dentition group, no significant differences existed for mandibular plane angle (ML/NSL) and interjaw-base angle (ML/NL) between openbite and deepbite subjects. However, the maxillary plane angle (NL/NSL) was, on average, 2.2 degrees larger ($p < 0.05$) in the deepbite group than in the openbite group. The values for anterior upper facial height (n-spa) and total facial height (n-gn) were significantly ($p <$ 0.001 and $p < 0.05$, respectively) greater (mean = 3.4 mm) in the deepbite group.

In the permanent dentition, the mandibular plane angle (ML/NSL) and interjaw-base angle (ML/NL) were, on average, 3.2 degrees larger ($p<0.01$ and $p < 0.05$, respectively) in the openbite group than in the deepbite group. Concerning the inclination of the upper jaw base (NL/NSL), no significant group difference was found. Anterior lower facial height (spa-gn) and anterior total facial height (n-gn) were significantly smaller (mean = 7.3 mm and 8.9 mm, respectively, $p < 0.01$) in the deepbite group than in the openbite group. The same was true for posterior total facial height (s-go; mean = 5.0 mm, $p < 0.05$).

Dentoalveolar compensatory mechanism

The dentoalveolar compensatory mechanism was analyzed using the following linear parameters: is-NL, isa-NL, ii-ML, iia-ML, ms-NL, msa-

Table 3
Linear correlation between the overbite and skeletal and dentoalveolar variables. Analysis of 191 high-angle subjects (ML/NSL ≥ 40° in the mixed dentition and permanent dentition

Variable	Mixed dentition (n = 144) r - value	Sig	Permanent dentition (n = 47) r – value	Sig
Skeletal				
ML/NSL	0.07	n.s.	-0.43	**
ML/NL	-0.07	n.s.	-0.33	*
NL/NSL	0.15	n.s.	-0.01	n.s.
s-go	0.08	n.s.	-0.41	**
n-gn	0.12	n.s.	-0.48	***
n-spa	0.33	***	-0.18	n.s.
spa-gn	-0.08	n.s.	-0.53	***
Dentoalveolar				
is-NL	0.46	***	0.02	n.s.
isa-NL	0.24	**	-0.06	n.s.
ms-NL	0.02	n.s.	-0.58	***
msa-NL	0.03	n.s.	-0.51	***
ii-ML	0.33	***	0.13	n.s.
iia-ML	0.24	**	0.11	n.s.
mi-ML	-0.11	n.s.	-0.35	*
mia-ML	-0.20	*	-0.47	***

*** = $p < 0.001$% level of significance
** = $p < 0.01$% level of significance
* = $p < 0.05$% level of significance
n.s. = no significance

Table 4
Occurrence (percentage, number) of habits in 71 high-angle subjects in the mixed dentition and 25 high-angle subjects in the permanent dentition. Division of the subjects with respect to the amount of overbite (OB): open bite (OB < 0 mm) and deep bite (OB > 4 mm)

Habits	Mixed dentition Openbite n = 13	Mixed dentition Deepbite n = 58	Permanent dentition Openbite n = 10	Permanent dentition Deepbite n = 15
Mouth breathing	61.5% (8)	48.3% (28)	50% (5)	46.7% (7)
Finger sucking and/or lip sucking and/or tongue-thrust swallowing	92.3% (12)	53.5% (31)	80% (8)	60% (9)

NL, mi-ML, mia-ML (Table 2).

In the mixed dentition, the deepbite group exhibited relative increases in the distances of the maxillary (mean = 3.8 mm, $p < 0.001$) and mandibular (mean = 3.1 mm, $p < 0.001$) incisor tips to their jaw bases when compared with the openbite group. In the molar region, on the other hand, no group differences in dentoalveolar heights existed. Measurements of the apex points showed the same tendency as those using the incisal and molar cusp tips as references.

In the permanent dentition, the deepbite group exhibited relative decreases of the distances of the maxillary (mean = 3.8 mm, $p < 0.001$) and mandibular (mean = 2.5 mm, $p < 0.05$) molar cusp tips to their jaw bases when compared with the openbite group. In the frontal region, on the other hand, no group differences in dentoalveolar heights were found. Again, measurements of the apex points showed the same tendency as those using the incisal and molar cusp tips as references.

The results of the correlation analysis are given in Table 3.

In the mixed dentition, a weak positive correlation ($r = 0.33$; $p < 0.001$) between overbite and anterior upper facial height (n-spa) was seen. Furthermore, overbite was significantly correlated with the distances of the maxillary ($r = 0.46$; $p < 0.001$) and mandibular ($r = 0.33$; $p < 0.001$) incisor tips to their jaw bases. The same was true for the maxillary and mandibular incisal apex points.

In the permanent dentition, weak negative correlations existed between overbite and the following parameters: mandibular plane angle ML/NSL ($r = -0.43$; $p < 0.01$), interjaw-base angle ML/NL ($r = -0.33$; $p < 0.05$), posterior total facial height s-go ($r = -0.41$, $p < 0.01$), anterior total facial height n-gn ($r = -0.48$, $p < 0.001$), and anterior lower facial height spa-gn ($r = -0.53$; $p < 0.001$). In addition, overbite correlated significantly with the distances of the maxillary ($r = -0.58$; $p < 0.001$) and mandibular ($r = -0.35$; $p < 0.05$) molar cusp tips to their jaw bases. Measurements of the maxillary and mandibular molar apex points showed the same tendency.

Habits

The occurrence of mouth breathing and the presence of other oral habits are shown in Table 4. A larger percentage of subjects with habits was found in the openbite group than in the deepbite group. This was especially true for the mixed-dentition subjects.

Discussion

To exclude interobserver variation and to minimize the error of the method, all lateral headfilms were traced by the same investigator. Both the digitizing error and the combined tracing and digitizing error were comparable with those of other studies.[6,14]

It would have been desirable to have longitudinal instead of cross-sectional data of untreated high angle subjects to improve our understanding of the nature of compensatory mechanisms; for ethical reasons, however, this was not possible.

In the present subject material, most (80%) high-angle cases exhibited either a normal overbite or a deepbite, which can be interpreted as acceptable compensation or overcompensation of the diverging jaw-base relationship. The skeletal characteristics and dentoalveolar compensatory mechanisms, however, differed with dental maturity. In the mixed dentition, the overcompensated (deepbite) high-angle group exhibited a relative posterior inclination of the maxilla (Figure 2) and relative extrusion of the maxillary and mandibular incisors (Figure 4). In the permanent dentition, on the other hand, the deepbite high-angle group exhibited a relative anterior inclination of the mandible (Figure 3) and relative intrusion of the teeth in the maxillary and mandibular molar regions (Figure 5).

A reason for the differing compensatory mechanisms in the two dental maturity groups might be sought in the masticatory muscle activity, which increases with age.[15] Electromyographic activity is known to be proportional to bite force,[16] and increased bite forces in the older (permanent dentition) subjects might have contributed to the compensation of the diverging jaw bases by a relative intrusion of the molars, thus hindering a posterior rotation of the mandible.

Another explanation for why some high-angle cases exhibited overcompensation of the divergent jaw-base relationship while others did not may be the influence of habits. A frontal openbite, as seen in the openbite group, was present more frequently in subjects with mouth breathing. Limme[10] claimed that the open-mouth position during mouth breathing induces a new postural position of the mandible, altering the pattern of growth toward a long face. Additionally, in mouth breathing children who had enlarged adenoids, Linder-Aronson[11] found a change in head and tongue posture leading to a typical facial appearance with a high mandibular plane angle, increased lower facial height, and frontal openbite.

In the present study, oral habits like finger or lip sucking and tongue-thrust swallowing were seen in a high percentage of subjects with insufficient or no compensation (openbite) of the vertical jaw-base divergency. This was true both for the mixed (92.3%) and permanent (80%) dentition groups. These findings are in concordance with those of several other authors[17-21] who found an association between oral habits and frontal openbite.

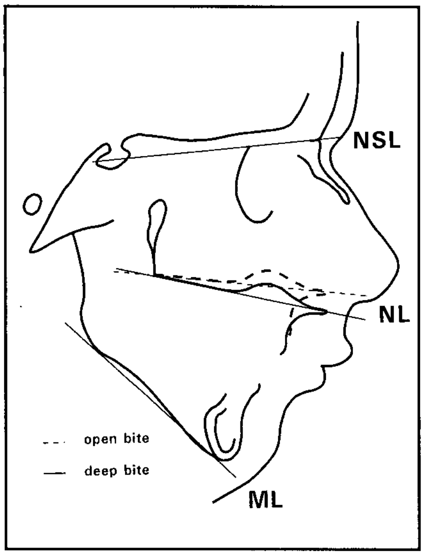

Figure 2
Schematic illustration of skeletal characteristics in overcompensated (deepbite) and insufficient/not compensated (openbite) mixed dentition high-angle cases.

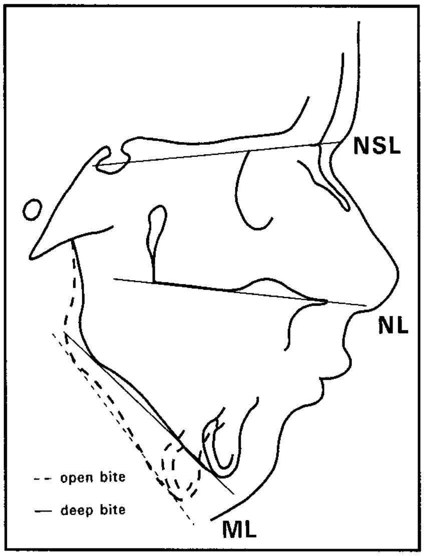

Figure 3
Schematic illustration of skeletal characteristics in overcompensated (deepbite) and insufficient/not compensated (openbite) permanent dentition high-angle cases.

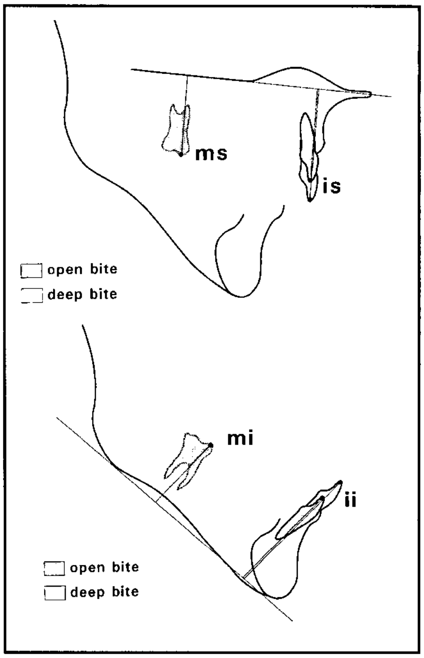

Figure 4
Schematic illustration of dentoalveolar compensatory mechanism in overcompensated (deepbite) and insufficient/not compensated (openbite) mixed dentition high-angle cases.

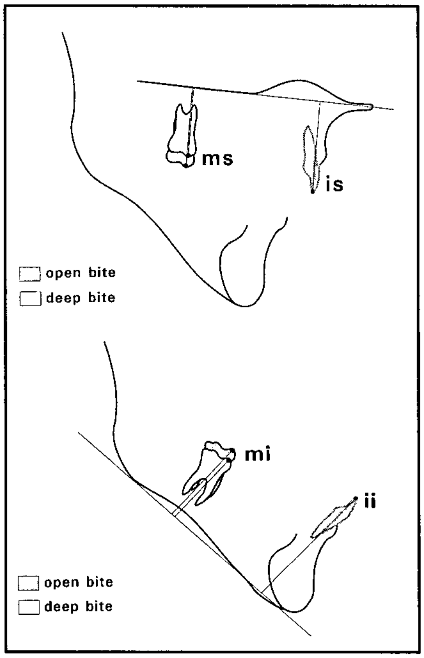

Figure 5
Schematic illustration of dentoalveolar compensatory mechanism in overcompensated (deepbite) and insufficient/not compensated (openbite) permanent dentition high-angle cases.

Conclusion

In conclusion, it can be said that in the majority of children (80%) with high-angle morphology, mandibular hyperdivergency is compensated for, resulting in a positive overbite. The skeletal characteristics and dentoalveolar compensatory mechanisms differ with dental maturity. Mouth breathing and other oral habits seem to have an impact on both the skeletal morphology and the compensatory mechanism. Studies are in progress to elucidate the effect of orthodontic treatment in compensated and noncompensated high-angle malocclusions.

References

1. Schudy FF. The rotation of the mandible resulting from growth: Its implications in orthodontic treatment. Angle Orthod 1965; 35:36-50.
2. Schendel SA, Eisenfeld PD, Bell WH, Epker BN, Mishelevich DJ. The long face syndrome: Vertical maxillary excess. Am J Orthod 1976; 70:398-408.
3. Linder-Aronson S. Adenoids: Their effect on mode of breathing and nasal airflow and their relationship to characteristics of the facial skeleton and the dentition. Acta Oto-Laryngol Suppl 1970; 265:3-132.
4. Riedel RA. Relation of maxillary structures to cranium in malocclusion and normal occlusion. Angle Orthod 1965; 35:142-145.
5. Solow B. The dentoalveolar compensatory mechanism: Background and clinical implications. Br J Orthod 1980; 7:145-161.
6. Pancherz H, Groten S. Dentoalveoläre Anpassung bei vertikalen Kieferbasisabweichungen. Fortschr Kieferorthop 1993; 54:10-16.
7. Isaacson JR, Isaacson RJ, Speidel TM, Worms FW. Extreme variations in vertical growth and associated variation in skeletal and dental variation. Angle Orthod 1971; 41:219-229.
8. Janson GRP, Metaxas A, Woodside DG. Variation in maxillary and mandibular molar and incisor vertical dimension in 12-year-old subjects with excess, normal, and short lower anterior face height. Am J Orthod Dentofac Orthop 1994; 106: 409-418.
9. Creekmore TD. Inhibition or stimulation of the vertical growth of the facial complex, its significance to treatment. Angle Orthod 1967; 37:285-296.
10. Limme M. Orthodontic consequences of mouth-breathing. Rev Belge Med Dent 1991; 46:39-50.
11. Linder-Aronson S. Der offene Biß in Relation zur Atmungsfunktion. Fortschr Kieferorthop 1983; 44:1-11.
12. Ballard CF. Variations of the posture and behaviour of the lips and tongue which determine the position of the labial segments: The implications in orthodontics, prosthetics and speech. Trans Europ Orthod Soc 1963; 39: 67-88.
13. Dahlberg G. Statistical methods for medical and biological students. New York: Interscience Publications, 1940.
14. Baumrind S, Frantz RC. The reliability of head film measurements. Am J Orthod 1971; 60:111-127.
15. Pancherz H. Temporal and masseter muscle activity in children and adults with normal occlusion. An electromyographic investigation. Acta Odontol Scand 1980; 38:343-348.
16. Hosman H, Naeije M. Reproducibility of the normalized electromyographic recordings of the masseter muscle by using the EMG recording during maximal clenching as a standard. J Oral Rehab 1979; 6:49-54.
17. Backlund E. Facial growth and the significance of oral habits, mouthbreathing and soft tissues for malocclusion. A study on children around the age of 10. Acta Odontol Scand 1963; 21:9-139.
18. Garattini G, Crozzoli P, Valsasina A. Role of prolonged sucking in the development of dentoskeletal changes in the face. Review of the literature. Mondo Ortod 1990; 15:539-550.
19. Tewari A. Abnormal oral habits relationship with malocclusion and influence on anterior teeth. J Indian Dent Assoc 1970; 42: 81-84.
20. Nahoum HI. Anterior open-bite: A cephalometric analysis and suggested treatment procedures. Am J Orthod Dentofac Orthop 1975; 67:513-521.
21. Nanda RS, Khan I, Anand R. Effect of oral habits on the occlusion in preschool children. ASDC J Dent Child 1972; 39:449-452.